Citation:

Raben A, Macdonald I, Astrup A. Replacement of dietary fat by sucrose or starch: effects on 14 d ad libitum energy intake, energy expenditure and body weight in formerly obese and never-obese subjects. *Int J Obes Relat Metab Disord.* 1997 Oct;21(10):846-59.

PubMed ID: 9347402

Study Design:

Crossover Case-Control Study

Class:

A - Click here for explanation of classification scheme.

Research Design and Implementation Rating:

NEUTRAL: See Research Design and Implementation Criteria Checklist below.

Research Purpose:

To investigate the impact of a high-sucrose diet vs a high-starch and a high-fat diet on 14 d *ad libitum* energy intake, body weight, energy expenditure and sympathoadrenal activity in normal weight-subjects with and without a history of obesity.

Inclusion Criteria:

- Normal weight, healthy women
- Post-obese women [PO] (BMI = 22.9 ± 0.7 kg/m^2) had a family history of obesity (at least one obese parent or sibling), had been more than 10% overweight (44 ± 10%) and had been weight stable for at least 2 months
- Never-obese controls [C] (BMI = 22.6 ± 0.4 kg/m^2) closely matched for age, weight, height, fat mass, and fat-free mass

Exclusion Criteria:

None of the cases had undergone surgical operations to become normal-weight.

Description of Study Protocol:

Recruitment

Recruitment methods not described.

Design: Crossover case-control study: Each subject completed three 14 d dietary periods, a sucrose-rich (sucrose), a starch-rich (starch) and a fat-rich (fat). The order of the periods differed, but subjects in the PO and C groups were ‘paired’ (except for two controls) so that the diet order was similar in the two groups. The dietary periods were separated by 2 to 6 wks.

Blinding used (if applicable): not applicable

Intervention (if applicable)

Before each experimental period, subjects were given a standardized, weight maintenance diet for 3 days. Each subject completed 3 dietary periods, *ad libitum*, for 14 days each:

- Sucrose-rich diet (59% carbohydrate, 23% from sucrose, 28% fat, 13% protein)
- Starch-rich diet (59% carbohydrate, 28% fat, 13% protein)
- Fat-rich diet (45 - 50% fat, 37-42% carbohydrate, 13% protein)
- Participants were supplied ad libitum amounts of the experimental diets to be consumed at home. The subjects collected the food twice a week and returned all leftovers for weighing and recording.

Statistical Analysis

- Initial group differences tested by t tests
- Other differences between the three diets and two groups were tested by parametric analysis of variance (ANOVA)
- In case of significance, a t test on least squares means (for unbalanced designs) was used to test for differences between groups or diets
- Simple linear regression analyses were performed within each diet

Data Collection Summary:

Timing of Measurements

- Before each experimental period, subjects were given a standardized, weight-maintenance diet for 3 days
- The third day was spent in a respiration chamber
- Subjects followed the diets *ad libitum* for 14 days
- On day 14, the subjects spent another day in the respiration chamber
- Blood samples were taken on day 15
- Body weight and composition were measured before and after each stay in the respiration chamber (days 1 and 15)
- At least 2 weeks and no more than 6 weeks separated the dietary periods

Dependent Variables

- 14 d *ad libitum* energy intake
- Body weight
- Body composition measured through bioelectrical impedance
- 24-hour energy expenditure
- Substrate oxidation rates
- Spontaneous physical activity
- Heart rate
- Appetite sensations
- Plasma catecholamine concentration
- Blood pressure
- Sympathoadrenal activity

Independent Variables

- Sucrose-rich diet (59% carbohydrate, 23% from sucrose, 28% fat, 13% protein)
- Starch-rich diet (59% carbohydrate, 28% fat, 13% protein)
- Fat-rich diet (45 - 50% fat, 37-42% carbohydrate, 13% protein)

Control Variables

- Subjects instructed not to change their physical activity pattern during or between the experimental diets

Description of Actual Data Sample:

Initial N: 20 women: 9 post-obese [PO], 11 matched controls [C]

Attrition (final N): as above

Age: mean age 39 ± 3 years for cases, 38 ± 3 years for controls

Ethnicity: not described

Other relevant demographics:

Anthropometrics subjects were matched for age, weight, height, fat mass and fat-free mass, but habitual energy and fat intake was lower and carbohydrate intake was higher in post-obese women than controls ($P < 0.05$).

Location: Denmark

Summary of Results:

Key Findings

- On the fat, starch and sucrose diet the actual intake of carbohydrate averaged 40.8, 59.1 and 58.6% ($P < 0.0001$), of sucrose 2.2, 2.6 and 23.2% ($P < 0.0001$), of fat 46.1, 28.0 and 28.6% ($P < 0.0001$) and of protein 13.1, 13.4, and 13.2% ($P < 0.05$), respectively.
- Average 14 d energy intake for all subjects was lowest on the starch diet (9.1 ± 0.4 MJ/d) compared with both the sucrose (10.3 ± 0.4 MJ/d) and fat diet (10.2 ± 0.4 MJ/d) ($P < 0.05$).
- Compared to a change of 0.0 kg, total body weight decreased on the starch diet by 0.7 ± 0.2 kg ($P<0.05$), but was unchanged on the fat (-0.3 ± 0.3 kg) and sucrose diet (0.2 ± 0.2 kg). The changes were significantly different between the starch and sucrose diets ($P < 0.05$).
- After 14 days on the sucrose diet, 24 hour energy expenditure as well as postprandial plasma adrenaline and noradrenaline concentrations, were significantly increased compared with the other two diets ($P < 0.05$)
- Overall satiety and palatability ratings were also highest on the sucrose diet ($P < 0.05$)

Author Conclusion:

In conclusion, a reduction in energy intake, body weight and fat mass was observed when normal-weight subjects with or without a history of obesity consumed a starch- and fiber-rich diet *ad libitum* for 14 days. In contrast to this, no significant changes in either of these parameters were observed on the sucrose-rich diet, however, 24-hour energy expenditure and sympathoadrenal

activity was increased, with no untoward effects on blood pressure, compared with the starch-rich and fat-rich diet. This can probably be explained by both the increased amount of carbohydrate, especially fructose (alone and from sucrose) consumed on the sucrose diet. Studies of longer duration, including both normal, obesity-prone and obese subjects are, however, still needed to evaluate the long-term health consequences of a high sucrose content in the diet.

Reviewer Comments:

Recruitment methods not described. Dietary interventions only 14 days long. Small numbers of cases and controls. Significant differences in habitual intake between groups.

Research Design and Implementation Criteria Checklist: Primary Research

Relevance Questions		
1.	Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (Not Applicable for some epidemiological studies)	Yes
2.	Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about?	Yes
3.	Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to nutrition or dietetics practice?	Yes
4.	Is the intervention or procedure feasible? (NA for some epidemiological studies)	Yes

Validity Questions		
1.	**Was the research question clearly stated?**	Yes
1.1.	Was (were) the specific intervention(s) or procedure(s) [independent variable(s)] identified?	Yes
1.2.	Was (were) the outcome(s) [dependent variable(s)] clearly indicated?	Yes
1.3.	Were the target population and setting specified?	Yes
2.	**Was the selection of study subjects/patients free from bias?**	???
2.1.	Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study?	???
2.2.	Were criteria applied equally to all study groups?	Yes
2.3.	Were health, demographics, and other characteristics of subjects described?	Yes

2.4.	Were the subjects/patients a representative sample of the relevant population?	???
3.	**Were study groups comparable?**	???
3.1.	Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT)	Yes
3.2.	Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline?	???
3.3.	Were concurrent controls used? (Concurrent preferred over historical controls.)	Yes
3.4.	If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis?	N/A
3.5.	If case control or cross-sectional study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.)	???
3.6.	If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")?	N/A
4.	**Was method of handling withdrawals described?**	Yes
4.1.	Were follow-up methods described and the same for all groups?	Yes
4.2.	Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.)	Yes
4.3.	Were all enrolled subjects/patients (in the original sample) accounted for?	Yes
4.4.	Were reasons for withdrawals similar across groups?	N/A
4.5.	If diagnostic test, was decision to perform reference test not dependent on results of test under study?	N/A
5.	**Was blinding used to prevent introduction of bias?**	Yes
5.1.	In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate?	N/A
5.2.	Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.)	Yes
5.3.	In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded?	N/A

5.4.	In case control study, was case definition explicit and case ascertainment not influenced by exposure status?	Yes
5.5.	In diagnostic study, were test results blinded to patient history and other test results?	N/A
6.	**Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were interveningfactors described?**	Yes
6.1.	In RCT or other intervention trial, were protocols described for all regimens studied?	Yes
6.2.	In observational study, were interventions, study settings, and clinicians/provider described?	N/A
6.3.	Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect?	Yes
6.4.	Was the amount of exposure and, if relevant, subject/patient compliance measured?	Yes
6.5.	Were co-interventions (e.g., ancillary treatments, other therapies) described?	Yes
6.6.	Were extra or unplanned treatments described?	N/A
6.7.	Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups?	Yes
6.8.	In diagnostic study, were details of test administration and replication sufficient?	N/A
7.	**Were outcomes clearly defined and the measurements valid and reliable?**	Yes
7.1.	Were primary and secondary endpoints described and relevant to the question?	Yes
7.2.	Were nutrition measures appropriate to question and outcomes of concern?	Yes
7.3.	Was the period of follow-up long enough for important outcome(s) to occur?	Yes
7.4.	Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures?	Yes
7.5.	Was the measurement of effect at an appropriate level of precision?	Yes
7.6.	Were other factors accounted for (measured) that could affect outcomes?	Yes
7.7.	Were the measurements conducted consistently across groups?	Yes
8.	**Was the statistical analysis appropriate for the study design and type of outcome indicators?**	Yes
8.1.	Were statistical analyses adequately described and the results reported appropriately?	Yes

	8.2.	Were correct statistical tests used and assumptions of test not violated?	Yes
	8.3.	Were statistics reported with levels of significance and/or confidence intervals?	Yes
	8.4.	Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)?	Yes
	8.5.	Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)?	Yes
	8.6.	Was clinical significance as well as statistical significance reported?	Yes
	8.7.	If negative findings, was a power calculation reported to address type 2 error?	No
9.	**Are conclusions supported by results with biases and limitations taken into consideration?**		Yes
	9.1.	Is there a discussion of findings?	Yes
	9.2.	Are biases and study limitations identified and discussed?	Yes
10.	**Is bias due to study's funding or sponsorship unlikely?**		???
	10.1.	Were sources of funding and investigators' affiliations described?	Yes
	10.2.	Was the study free from apparent conflict of interest?	???